Reducing the manufacturing cost of carbon fibers

OAAT ACCOMPLISHMENTS

Microwave Production of Carbon Fibers

Challenge

Carbon fibers can reduce the weight of automotive parts by over 60%, while retaining comparable mechanical properties to heavier materials. Since capital costs represent a substantial portion of the total cost of carbon fiber production, a low-cost manufacturing process could significantly reduce the expense of carbon fibers.

Plasma/microwave production of carbon fibers reduces manufacturing cost up to 27% and processing time up to 30 times (shown is plasma processing system).

Technology Description

Carbon fibers were manufactured from a polyacrylonitrile-(PAN) based precursor, the typical feedstock for conventional carbon fiber manufacturing processes. Aspects of a continuous microwave process were developed at a laboratory-scale level. A stable, atmospheric, open plasma was used to convey the microwave power to the target feedstock. The direct microwave heating unit uses a long cavity, designed as a modular structure, to accommodate additional lengths and plasma treatments in the further development of a continuous process. Other peripheral equipment, such as a fiber preheater, was developed to support the microwave process.

Accomplishments

This project demonstrated the technical feasibility of using microwave-assisted plasma technology to produce carbon fibers from PAN precursors. The project built a laboratory-scale, continuous carbon fiber processing unit. Microwave processing times of 5-8 minutes compare favorably with conventional processing times of 40-90 minutes.

To control the quality of the carbon fibers produced, an in-situ, real-time diagnostic monitoring system was developed. This high-temperature (up to 650° C) dielectric measurement system is able to measure critical properties of the carbon fibers under actual processing conditions. The microwave technology produces carbon fibers with properties – density, electrical resistivity, fiber diameter, effective tow area – comparable to those made by conventional processes.

Data obtained from the measurement system were used to develop a computer simulation model that characterizes the microwave direct heating of carbon fibers at various stages of the manufacturing process. Modeling allows further testing and refinement of the continuous manufacturing process.

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Benefits

- Lightweight carbon fibers have sufficient mechanical integrity to replace heavier materials in critical automotive parts. Lighter weight improves vehicle fuel economy.
- The microwave technology can replace 40-50% of a conventional processing line, which accounts for 25-40% of the total processing costs (capital and operating). This process alone could yield a 20% reduction in carbon fiber price.

Future Activities

- Further refine the continuous carbon fiber processing unit to prepare for commercialization.
- Develop more sophisticated computer modeling to more precisely control the quality of the carbon fibers produced.
- Further develop supporting systems for the microwave process.
- Produce sufficient quantities of carbon fiber for mechanical testing.

Partners in Success

- Akzo Fibers
- Hexcel Fibers
- Oak Ridge National Laboratory
- USCAR's Automotive Composites Consortium
  (Ford Motor Company, General Motors Corporation, DaimlerChrysler Corporation)